WOODS HOLE OCEANOGRAPHIC INSTITUTION

Reference No. 63-13

CURRENT MEASUREMENTS EMPLOYING THE RADIO DROGUE SYSTEM

WOODS HOLE, MASSACHUSETTS

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Charles E. Parker

March 1963

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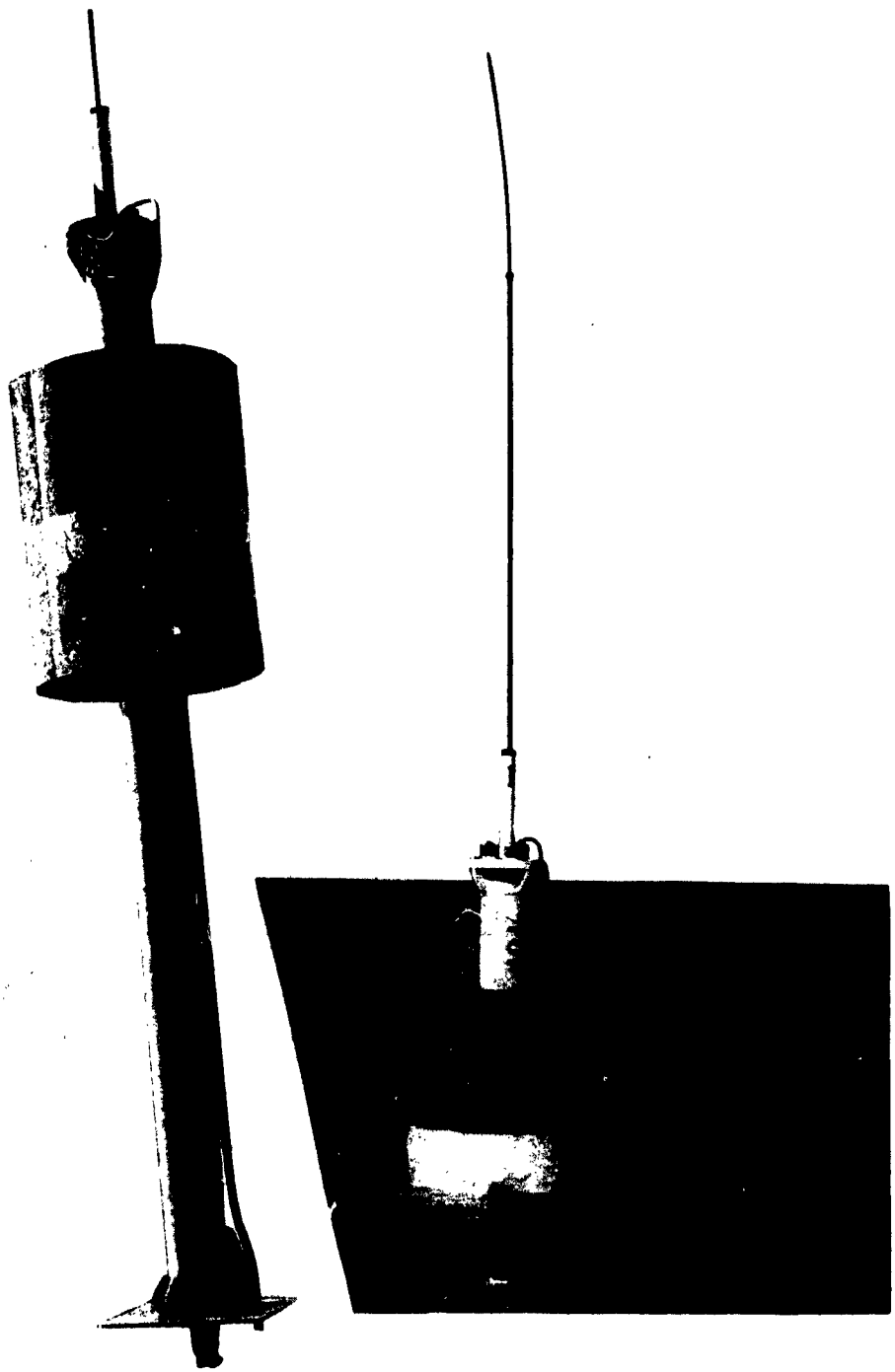

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ABSTRACT

The following report describes the results obtained from three Radio Drogues placed about 140 miles South of the Bermuda Islands in June 1962. The current flow plotted was at a depth of 1000 meters. A total of 2,460 miles of track was realized by periodic location of each drogue by aircraft over a period of four months. The main circulation feature described is an eddy that covers approximately 60,000 square miles.

CURRENT MEASUREMENTS EMPLOYING THE RADIO DROGUE SYSTEM

Introduction:

Recently direct current measurements have been made in an area South and Southeast of Bermuda covering approximately 72,000 square miles using the Radio Drogue System developed at the Woods Hole Oceanographic Institution under Nonr Contract 3351-7.

The data presented here is concerned with observations of three 64 foot diameter drogues which were set at 1000 meters in depth and followed from mid June 1962 to the end of October 1962.

Although some aspects of the data are immediately apparent such as the description of a large eddy encompassing about 34,000 square miles and evidence of a second one of equal size, there are indications that oscillations due to large tidal effects are present.

Scope of the Experiment

The three 1000 meter radio drogue units, such as those shown in Figure 1, were set near 29° 50'N and 64° 41'W within a period of six days during CRAWFORD Cruise No. 78 in mid June 1962. After three days of final checks on the equipment and plotting of their speed and direction, they were left to continue drifting while the ship returned to Woods Hole.

On 6 July 1962, the first of 18 aircraft search flights were undertaken using a Navy R4D operated by Woods Hole Oceanographic Institution. Figure 2 gives the positions of each drogue and the dates of these flights up to 18 October 1962. Buoy No. 5 is believed to have broken loose from its drogue chute after position No. 3. Its progress from this point was to the westward and can be followed in Figure 3.

At the end of the experiment the disposition of each unit was as follows: Figure 3.

1. Number 4 was picked up by the U. S. Destroyer WILLARD KEITH at 30° 00'N and 64° 00'W on 24 October 1962.

2. Number 5 was retrieved during CRAWFORD Cruise No. 89 on 3 November 1962. Only 25 feet of its original cable remained attached to the buoy. Its position at this time was 29° 20'N and 72° 43'W. This buoy had encountered two hurricanes, Daisy and Ella, towards the end of the experiment. The radio was still operational and was capable of being interrogated 200 miles away.

3. Number 6 was last sighted on 18 October and was moving towards the NNE. An attempt to locate this unit during CRAWFORD Cruise No. 89 was thwarted due to severe storms at that time. The unit was estimated to be about 200 miles from our closest point of approach.

A total of 170.3 hours (25,545 miles) actual flight time was used during the program to obtain 2,460 miles of drogue track.

Observations

The general movement of the water at the 1000 meter level in this area showed an average speed of 15.9 cm/sec on an elliptical path, which moved No. 4 drogue to within 3 miles of its previous position after 110 days!

For the first 85 days all three were well coupled in both direction and velocity, Figures 4, 5, and 6. It is felt that No. 5 lost its drogue chute near the midway point and had encountered a faster moving western surface flow. Even though it no longer could be used as a 1000 m drogue, a certain amount of surface drift information can be gathered from about the 60th day until the 120th day. Velocity differentials between the surface and 1000 m are not as high as one would expect. Figure 4.

Visual sightings were made on all three units from the 60th day up to the last fix and from their attitude in the water an accurate determination of their status was ascertained.

No. 5 was riding above its normal waterline and definitely indicated a loss of its cable and chute. Nos. 4 and 6 were at their normal waterlines and their motion in the water showed the full load to be intact.

A strong disturbance in the southeast quadrant of the studied area is shown by the divergent tracks of drogues 4 and 6, one moving clockwise toward the SE; the other counterclockwise toward the SW. After this period the movements of both No. 4 and No. 6 from points 12 to 18 (Figure 2) were nearly parallel, 028° T and 033° T,

of comparable velocity, 10.2 cm/sec and 8.25 cm/sec, and on the same general latitude.

It is logical to speculate on the complexities involved in this type of rapid divergence. The two drogues moved at an angle of 90° away from each other showing almost identical arcs. These particular plots, 5 - 6 - 8 and 10 were made one, two and three days apart respectively giving a good picture of the pattern as it developed. Upon reaching the southern most part of the eddy, No. 4 was apparently transported to the west by a dominant flow running along the eddy's southern side until moved out again into the first back eddy. This same flow might well be responsible for the formation the first described eddy and the second or twin back eddy to the east and north. Figure 7 shows one possible flow pattern for this circumstance.

A second observation is concerned with the plot of the North-South component of the drift against time. (Figure 8). A reference level of 30° N was used for a base for the plot. Included in the figure is a representation of a 27.5 day lunar monthly tide cycle. It is interesting to note that portions of the observed fluctuations appear to coincide with this tide cycle. It is possible that a phenomenon of this nature takes the form of large scale oscillations which shift the entire eddy system rather than imposing undulations on the main flow alone.

By superimposing these oscillations on the moving track without appreciable change in the original N-S component and adjusting

the speed and change in direction for agreement between points of equal time, it is possible to construct flow chart showing continuity between individual drogues. Figure 7.

It must be kept in mind that some of the observed points were separated by periods of up to 25 days, the average being 11 days, and much is to be desired as to the real movement between plots. In view of this fact it is, of course, an imaginative presentation and only states one of probably many solutions.

It was gratifying to see that the results of this test program were in such good agreement considering the small number of units. With an increase in the number of drogues, their operational life and sampling rate, a more detailed survey is possible that will serve to fill in many of the gaps. The next logical step should also be an increase in sensor information on the original vehicle to obtain even more definitive information.

LIST OF FIGURES

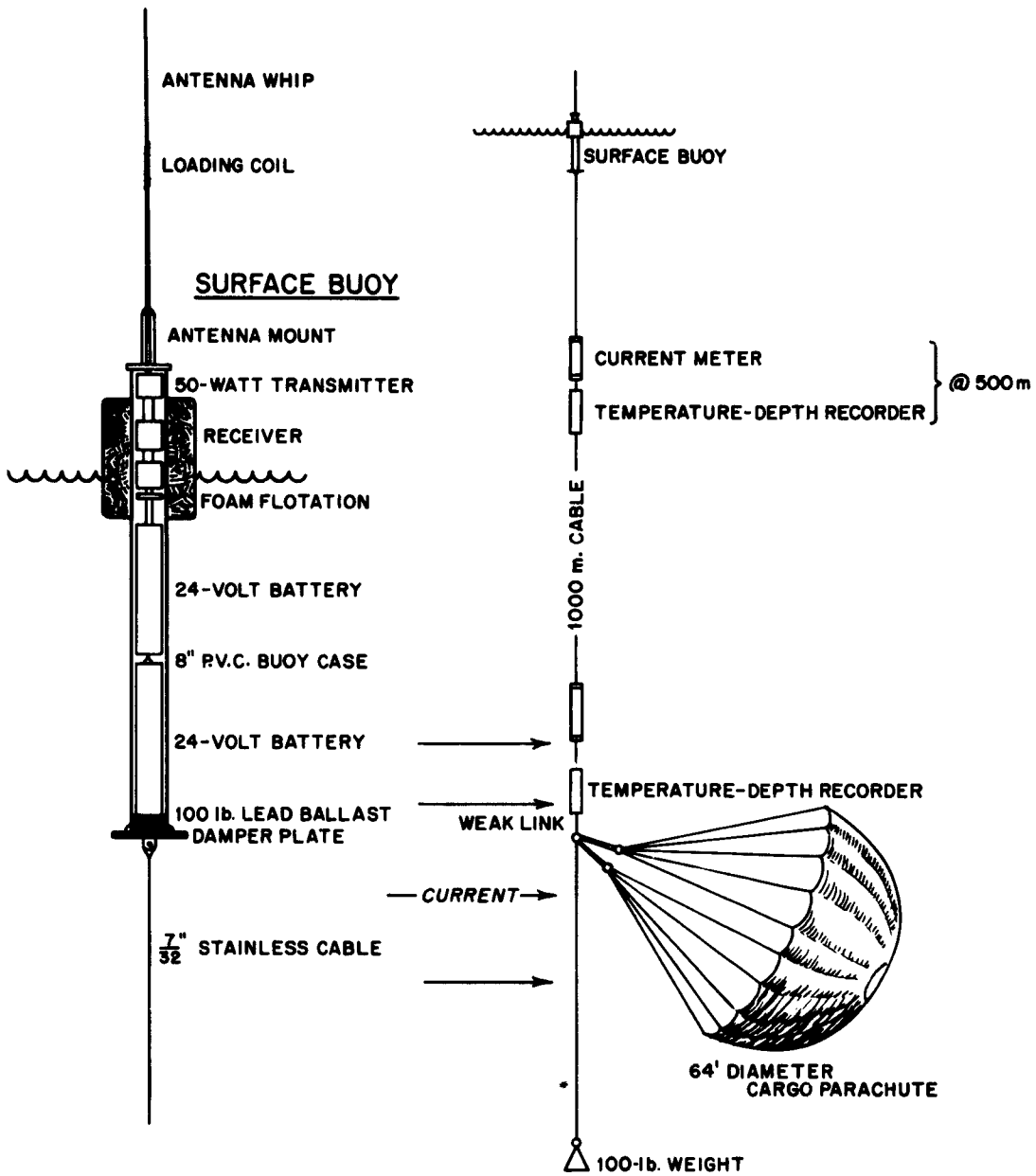

FIGURE 1. RADIO DROGUE LAYOUT

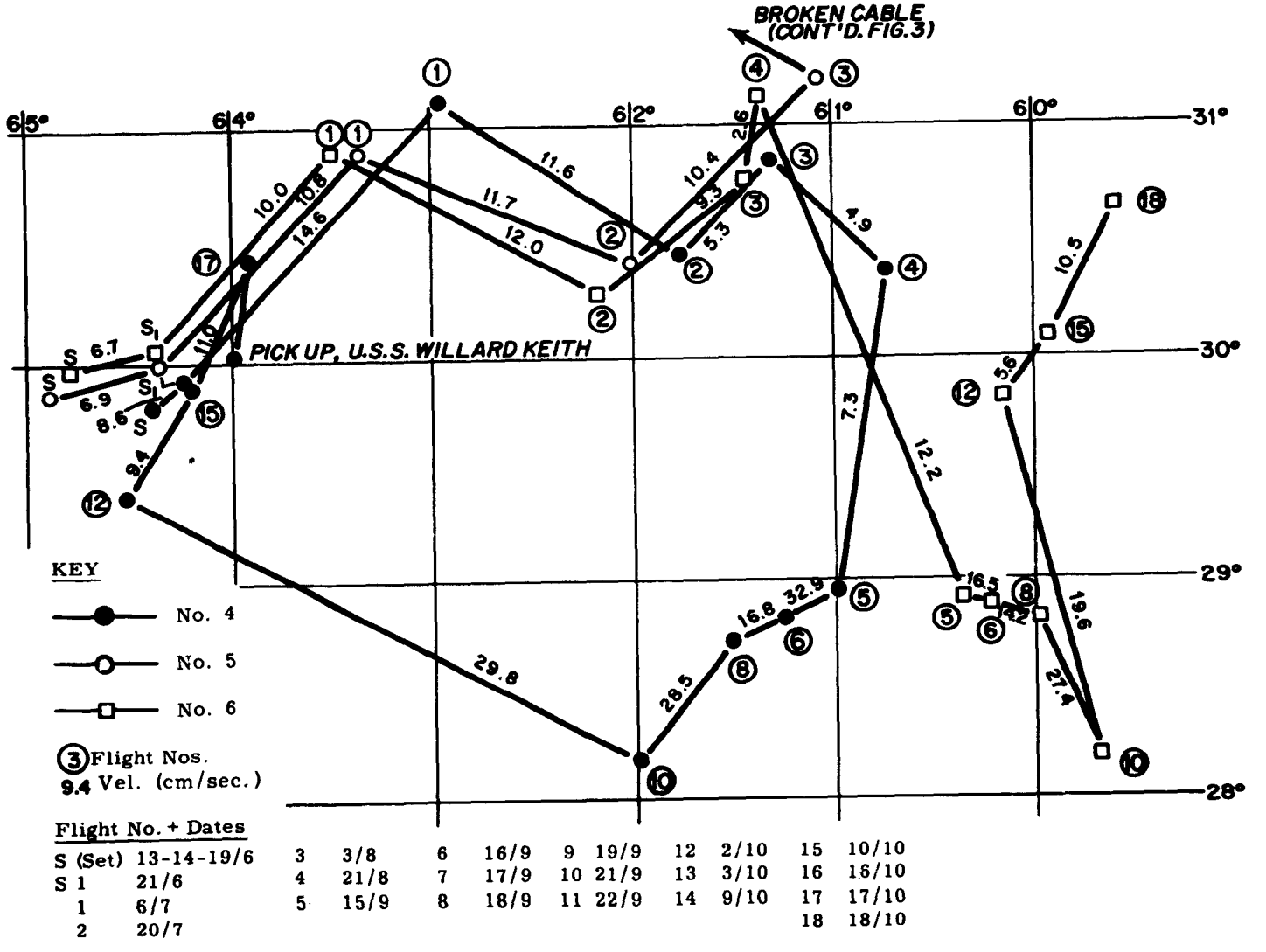

FIGURE 2. RADIO DROGUE TRACK, 1000 METERS

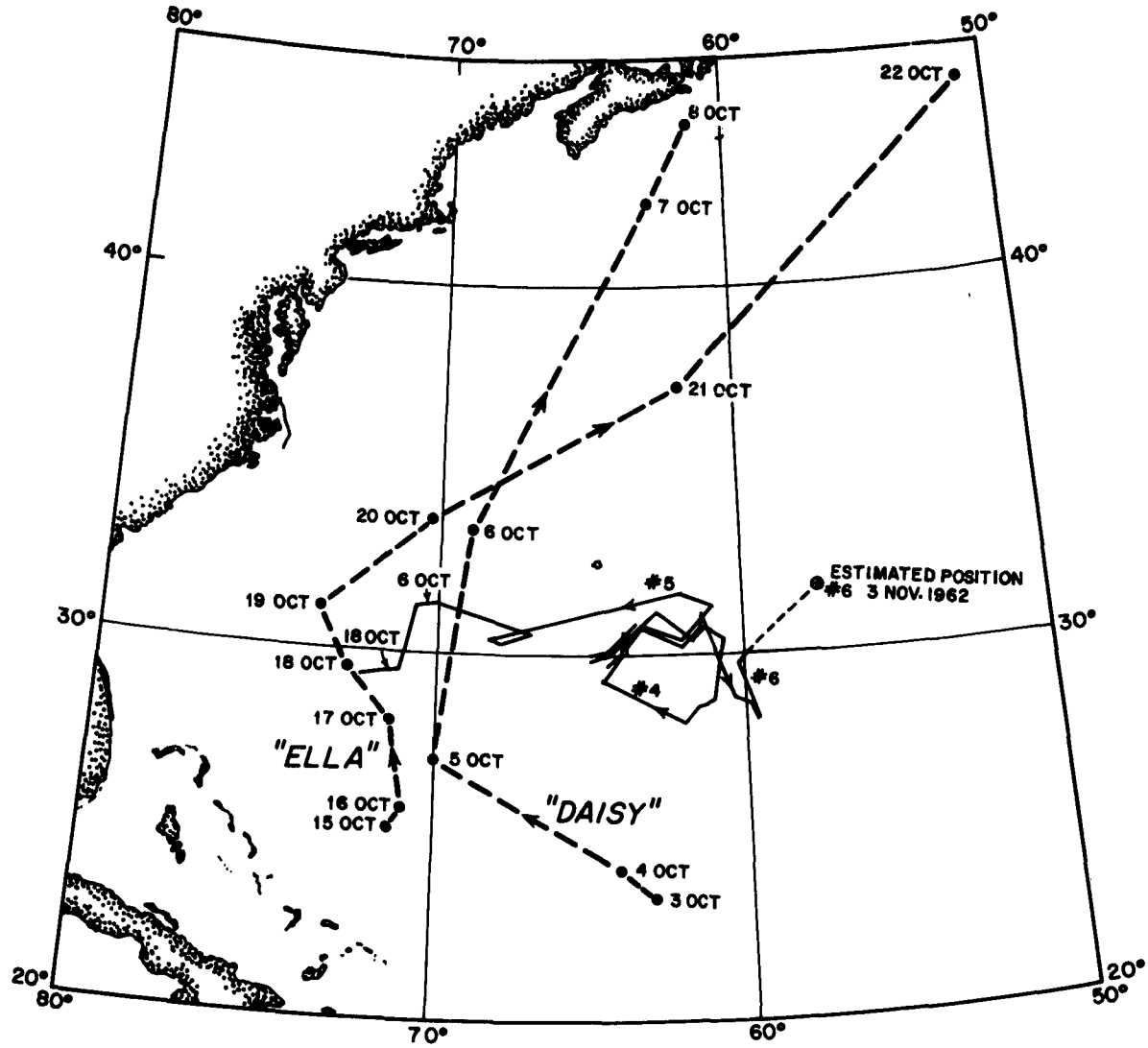

FIGURE 3. COMPLETE TRACKS OF DROGUES 4, 5, 6 AND HURRICANES "ELLA" AND "DAISY".

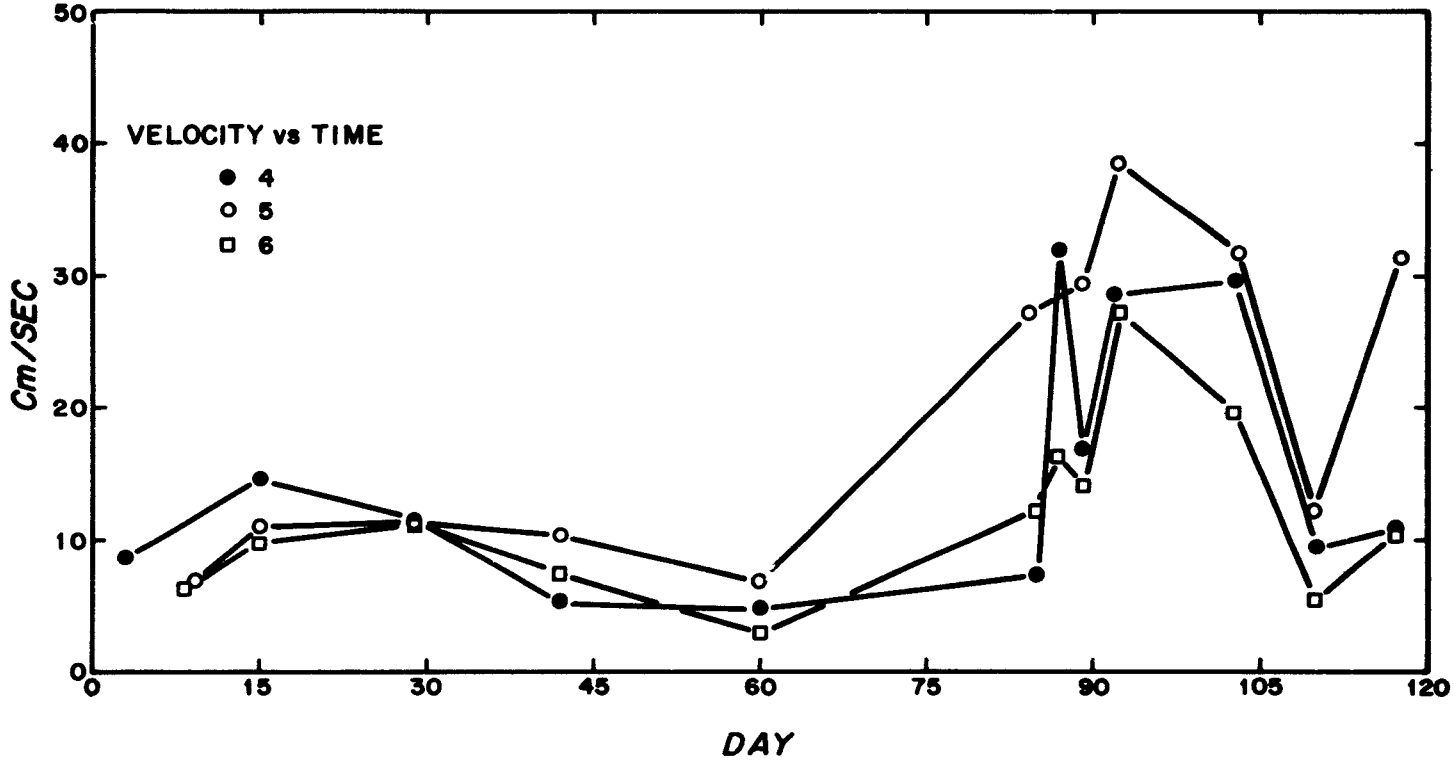

FIGURE 4. VELOCITY VS TIME

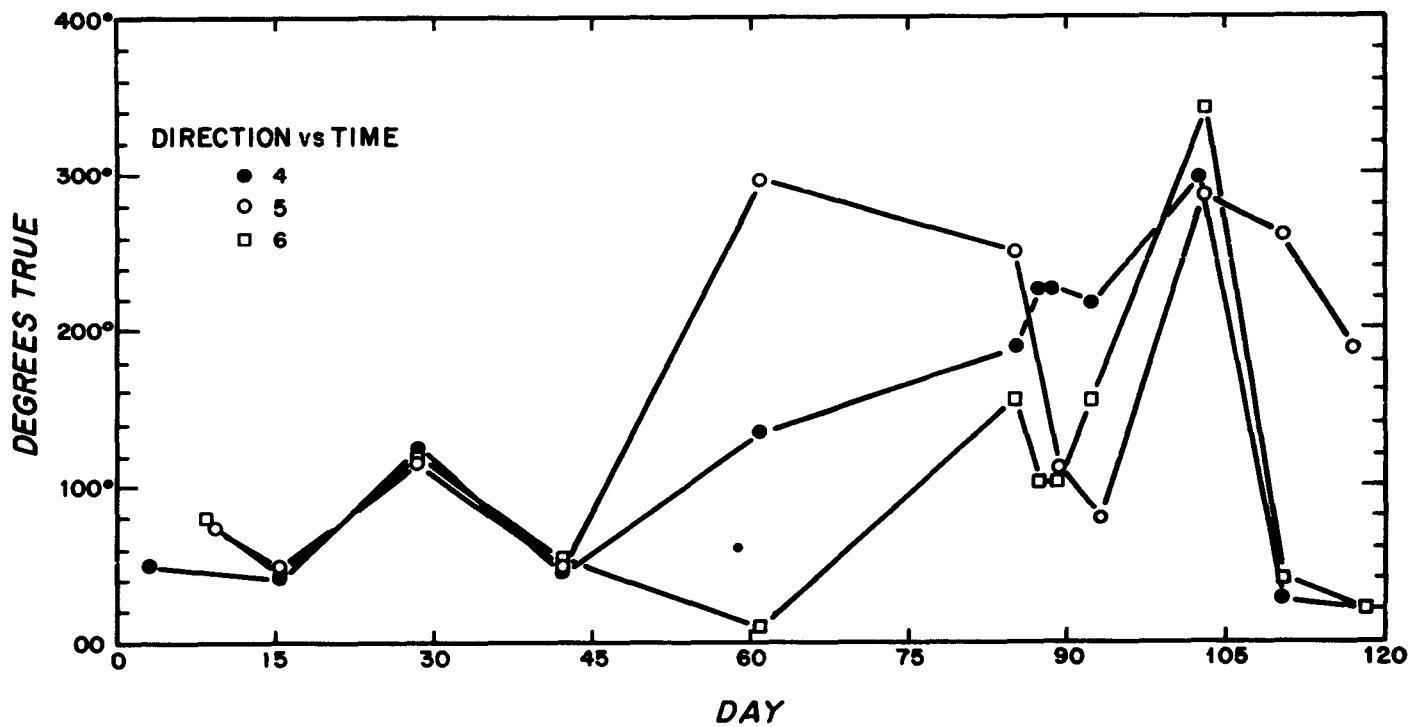

FIGURE 5. DIRECTION VS TIME

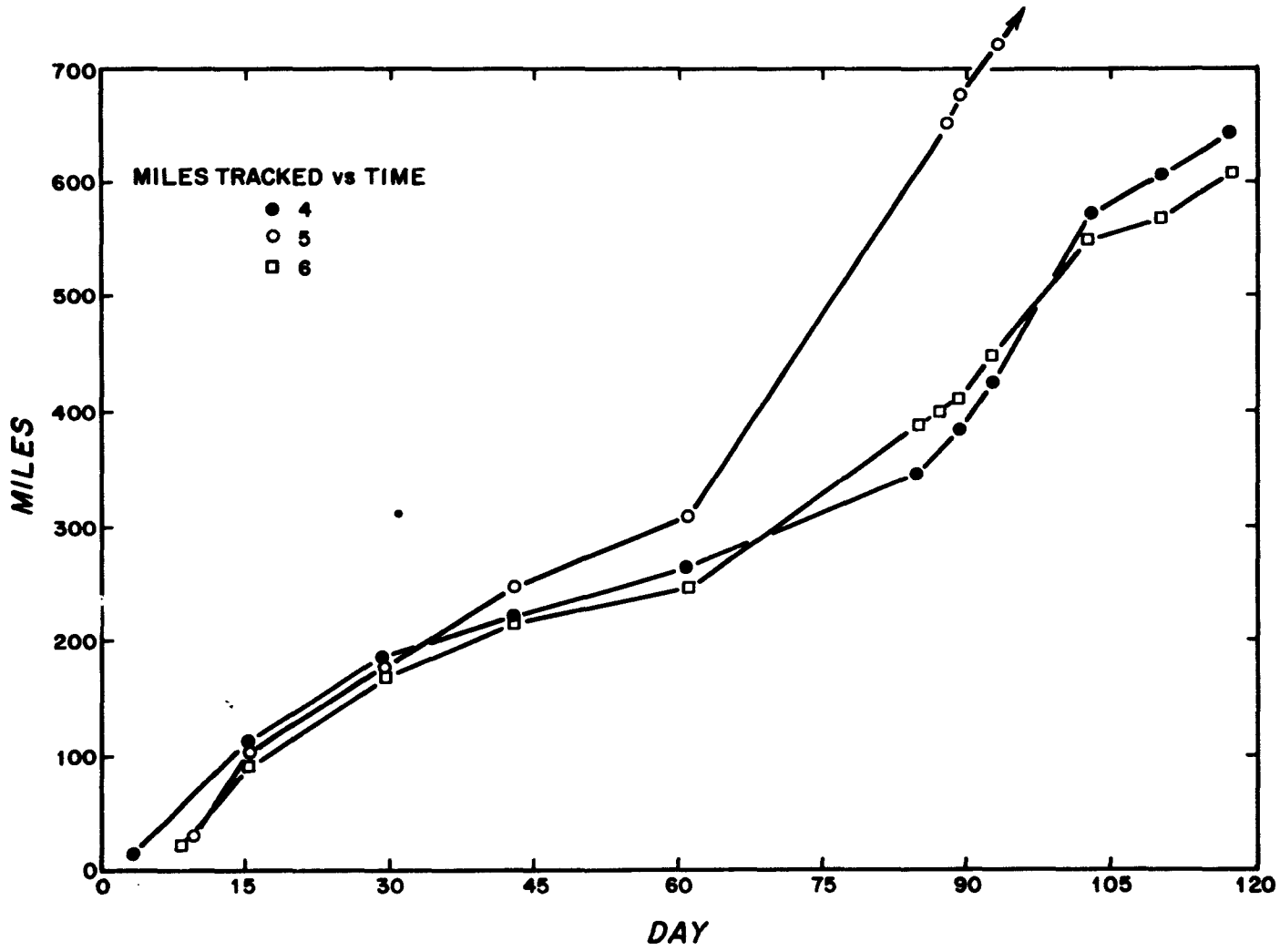

FIGURE 6. MILES TRACKED VS TIME

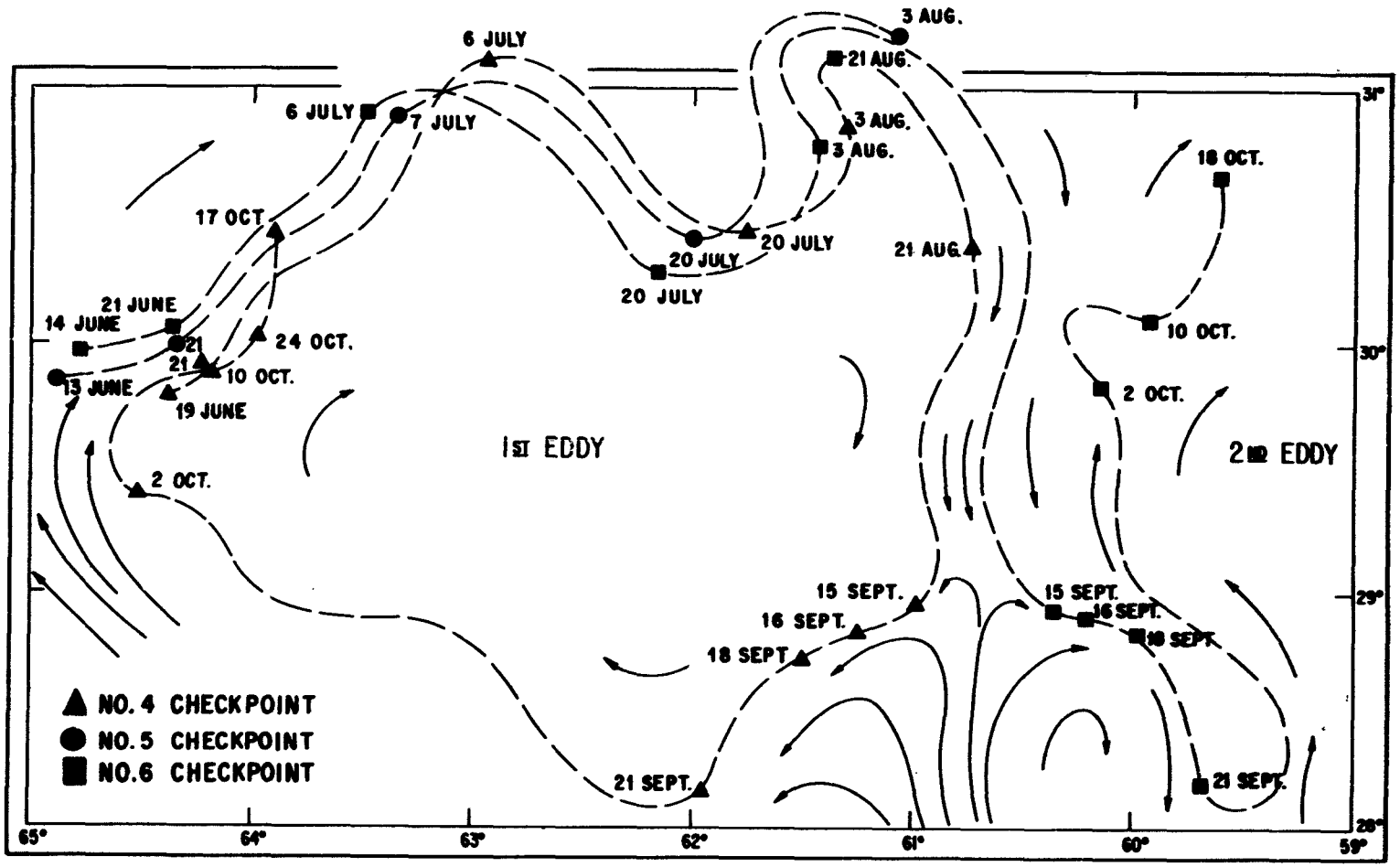

FIGURE 7. SPECULATIVE FLOW PATTERNS

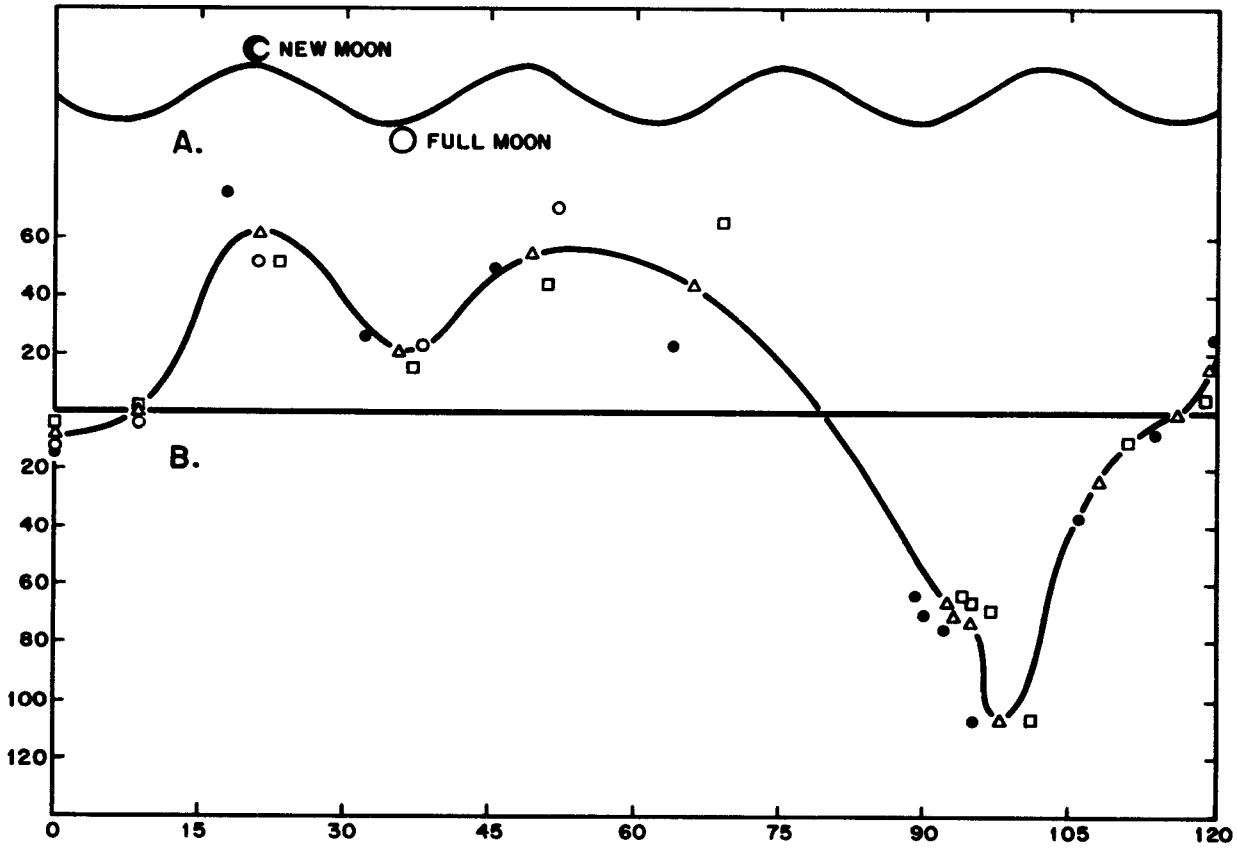

FIGURE 8. a) 27.5 DAY LUNAR MONTHLY TIDAL CYCLE
b) N-S COMPONENT VS TIME

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The following report describes the results obtained from three Radio Drogues placed about 140 miles South of the Bermuda Islands in June 1962. The current flow plotted was at a depth of 1000 meters. A total of 2,400 miles of track was realized by periodic location of each drogue by aircraft over a period of four months. The main circulation feature described is an eddy that covers approximately 60,000 square miles.

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2. Circulation of Eddy Systems

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